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# JOURNAL OF MOLECULAR CATALYSIS A: CHEMICAL

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## CATALYST PREPARATION AND REGENERATION

**5935889**

### Catalyst and method of preparation

Murrell, Lawrence Lee; Overbeek, Rudolf Alfred; Khonsari, Ali M. South Plainfield, Chatham Township, Bloomfield, NJ, USA. Assigned to ABB Lummus Global

Catalyst particles are prepared by coating a core particle, which is usually catalytically inert with respect to the intended chemical reaction, in a fluidized bed coating apparatus. The coating technique involves repeatedly applying and drying small quantities of an atomized slurry containing the coating material in the form of a colloidal dispersion or in the form of very fine, non-colloidal particles preferably mixed with colloidal particles. In this way, incremental layers are formed to produce a final thin shell that has a highly uniform thickness, which is formed on the surface of the core and which does not penetrate porous cores. Various methods are disclosed for converting the coated particles to the desired catalyst form.

**5935892**

### Supported phase catalyst

Davis, Mark E.; Wan, Kam To Pasadena, St. Louis, MO, USA. Assigned to California Institute of Technology

Supported phase catalysts in which the support phase is highly polar, most preferably ethylene glycol or glycerol, are disclosed. An organometallic compound, preferably a metal complex of chiral sulfonated 2,2'-bis(diphenylphosphino)-1,1'-binaphthyl (BINAP) is dissolved in the support phase. Such supported phase catalysts are useful for asymmetric synthesis of optically active compounds, including the asymmetric hydrogenation of prochiral unsaturated carbon-hetero atom bonds, such as ketones, imines and beta-keto esters. The phenyl groups of the BINAP ligand are at least mono-sulfonated and the ligand overall is tetra- to hexa-sulfonated. Ruthenium is the preferred metal.

**5935895**

### Heterogeneous catalysts

Baiker, Alfons; Dutoit, Dominique; Hutter, Remo Glatbrugg, Eggliswil, Kriessern, Switzerland. Assigned to Roche Vitamins

A silica-titania mixed oxide catalyst and its method of manufacture is disclosed. Such catalysts can be used

especially to catalyze the epoxidation of olefinically unsaturated compounds with organic hydroperoxides.

**5939220**

### Catalyst

Gunner, Alec Gordon; Hyde, Timothy Ian; Potter, Robert John; Thompsett, David Longfield, Reading, Chalkhouse Green, Reading, Great Britain. Assigned to Johnson Matthey

A novel catalyst comprising a Pt-M alloy wherein M is one or more metals selected from the transition metal elements or from Groups IIIA or IVA of the Periodic Table in "Handbook of Chemistry and Physics" 64th Edition, CRC Press, and Y wherein Y is a bronze-forming element or an oxide thereof, characterized in that the Pt-M alloy is in intimate contact with Y, and provided that M is not Ru if Y is WO<sub>3</sub> is disclosed and which may be used as a poison tolerant catalyst for use in fuel cells, specifically as the anode of a PEM fuel cell.

**5939349**

### Method of preparing non-zeolitic molecular sieve catalyst

Kibby, Charles L.; Provance, Ross L. Benicia, Richmond, CA, USA. Assigned to Chevron USA

An improved process is provided for adding a hydrogenation component to a non-zeolitic molecular sieve catalytic particulates with minimal loss in micropore volume for improved performance catalytic performance. The process includes adding an active source of the hydrogenation component dissolved in a non-aqueous solvent.

**5939353**

### Method for preparing and using nickel catalysts

Bhattacharyya, Alakananda; Chang, Wen-Dong; Kleefisch, Mark S.; Udovich, Carl A. Wheaton, Houston, Plainfield, Joliet, IL, USA. Assigned to BP Amoco

A direct, simplified and relatively salt-free process is described for making anionic, hydrotalcite-type pillared clay compositions which contain nickel, and their heat-treated derivatives. Compositions of the invention are manufactured from reactants that contain a relatively minor amount of metal salts or, preferably, contain essentially no metal salts. Preferred compositions made by the process form a number of new nickel-containing

catalytic materials which are unusually resistant to deactivation, for example resistant to coke formation when used to catalyze chemical conversions of a hydrocarbyl compound with an oxygen-containing gas at elevated temperatures to form synthesis gas.

**5942458****Regeneration of spent As-poisoned lead catalysts**

Berthier, Paul; Bournonville, Jean-Paul; Ladirat, Christian; Nocher, Bernard La Garde Adhemar, Rousson, Saint-Laurent des Arbres, La Celle Saint Cloud, France. Assigned to Procatalse

Spent lead catalysts containing contaminating amounts of arsenic values, e.g., mixed oxides of lead and arsenic, are regenerated and rendered suitable for reuse by heat-treating same at a temperature of at least 550C in the presence of a gas mixture which comprises an inert gas, e.g., Ar, N<sub>2</sub> or He, and at least 2% by volume of at least one reducing gas, e.g., H<sub>2</sub>, CO or CH<sub>4</sub>.

**5945459****Preparation of high activity catalysts; the catalysts and their use**

Mauldin, Charles H. Baton Rouge, LO, USA. Assigned to Exxon Research and Engineering

A process for the preparation of a catalyst useful for conducting carbon monoxide hydrogenation reactions, especially a Fischer–Tropsch catalyst, use of the catalyst for conducting such reactions, especially Fischer–Tropsch reactions, and the composition produced by said process. In the preparation of the catalyst, a solution of a multi-functional carboxylic acid having from about three to six total carbon atoms, preferably about four to five total carbon atoms, is employed to impregnate and disperse a compound or salt of rhenium and a compound or salt of a catalytic metal, or metals, e.g., copper or an iron group metal such as iron, cobalt, or nickel onto a refractory inorganic oxide support, e.g., titania. The rhenium, which need be present only in small amount permits full and complete reduction of the catalytic metal, or metals, dispersed by the acid. Higher catalyst activities with lower rhenium loading are thus achieved than in previous preparations where higher concentrations of rhenium were required to both effectively disperse, and reduce the catalytic metal, or metals, during the preparation. Surprisingly, as little as about one-tenth of the rhenium is required to accom-

plish the reduction promotion where the dispersion is effected with the acid.

**5948377****Catalyst composition**

Sung, Shiang New York, NY, USA. Assigned to Engelhard

A catalyst composition comprising at least one first supports, at least one first precious metal component, at least one second supports, and at least one second precious metal component. The total amount of the first precious metal component comprises from 1 to 99 wt.% based on the total of the first and second precious metal components. The surface area of the at least one first support is greater than the surface area of the at least one second support. Optionally or alternatively, the average particle size of the at least one first supports is greater than the average particle size of the at least one second supports. The present invention includes a method to prepare the catalyst composition and a method to use the catalyst composition as a three-way catalyst.

**5948722****Method for producing iron-based catalysts**

Farcasiu, Malvina; Kaufman, Phillip B.; Diehl, J. Rodney; Kathrein, Hendrik Pittsburgh, McMurray, PA, USA. Assigned to The United States of America as represented by the United States Department of Energy

A method for preparing an acid catalyst having a long shelf-life is provided comprising doping crystalline iron oxides with lattice-compatible metals and heating the now-doped oxide with halogen compounds at elevated temperatures. The invention also provides for a catalyst comprising an iron oxide particle having a predetermined lattice structure, one or more metal dopants for the said iron oxide, said dopants having an ionic radius compatible with said lattice structure; and a halogen bound with the iron and the metal dopants on the surface of the particle.

**5948723****Layered catalyst composite**

Sung; Shiang New York, NY, USA. Assigned to Engelhard

A catalyst composition and layered catalyst composite of the type generally referred to as a three-way conversion catalyst having the capability of substan-

tially simultaneously catalyzing the oxidation of hydrocarbons and carbon monoxide and the reduction of nitrogen oxides. The catalyst composition comprises at least two supports, at least one first precious metal component. There is at least one lanthana stabilized alumina support, and at least one refractory oxide unstabilized support. The composition further comprises at least one precious metal component located on the lanthana stabilized alumina support and the unstabilized support. There is an oxygen storage composition comprising, 40 to 80 wt.% of a diluent component, 10 to 60 wt.% of a cerium component, 1 to 15 wt.% of a neodymium component, and 1 to 15 wt.% of a praseodymium component. The composition also comprises at least one alkaline earth metal stabilizer and a zirconium component.

#### **5952259**

##### **Process for making an acid–base leached zeolite catalyst**

Drake, Charles A.; Wu, An-hsiang Nowata, Bartlesville, OK, USA. Assigned to Phillips Petroleum

A catalyst composition and a process for converting a hydrocarbon stream such as, for example, gasoline to olefins and  $C_6$  to  $C_8$  aromatic hydrocarbons such as toluene and xylenes are disclosed. The catalyst composition comprises an alumina and a silica, wherein the weight ratio of aluminum to silicon is in the range from about 0.002:1 to about 0.25:1. The process comprises contacting a hydrocarbon stream with the catalyst composition under a condition sufficient to effect the conversion of a hydrocarbon to an olefin and a  $C_6$  to  $C_8$  aromatic hydrocarbon. Also disclosed is a process for producing the catalyst composition which comprises: (1) contacting a zeolite with an effective amount of a base under a condition sufficient to effect a reduction in silicon content of said zeolite to produce a base-leached zeolite; and (2) contacting said base-leached zeolite with an effective amount of an acid under a condition sufficient to effect a reduction in aluminum content of said base-leached zeolite.

#### **ENVIRONMENTAL CATALYSIS**

#### **5937632**

##### **Method for operating a gas turbine group with catalytic gas generator**

Dobbeling, Klaus; Griffin, Timothy Windisch, Ennetbende, Switzerland. Assigned to ABB Research

In the case of a method for operating a gas turbine group, the gas turbine group essentially consists of a

compressor, a combustion chamber, a turbine and a generator. Fuel is mixed in a premixer of the combustion chamber, prior to the combustion, with air compressed in the compressor, and subsequently burned in a combustion space. Compressed air, fed via an air line element, is mixed with fuel fed via a fuel line element and delivered to a reactor having a catalytic coating. The air/fuel mixture is converted in the reactor into a synthesis gas comprising hydrogen, carbon monoxide, residual air and residual fuel and this synthesis gas is injected into the zones of the combustion chamber where the flame is stabilized.

#### **5942195**

##### **Catalytic plasma exhaust converter**

Lecea, Oscar Alfonso; Touse-Shunkwiler, Sara Ann El Paso, Grand Blanc, MI, USA. Assigned to General Motors

A catalytic plasma converter combines oxidation and reduction of exhaust gas emissions such as HC, CO, NO and  $NO_x$  by providing a pair of catalytic metallic porous elements, such as electrically conductive metal matrix material, spaced apart to define an intermediate reaction chamber. High voltage electric charges of opposite polarity applied to the two elements generate a gas plasma in exhaust gases passing through the converter reaction chamber. Passage of gases through the catalytic elements oxidizes CO and HC emissions present in the exhaust gases while the gas plasma in the reaction chamber causes reduction of NO and  $NO_x$  and further reaction of HC and CO exhaust emissions.

#### **5943771**

##### **Method of making a catalytic converter for use in an internal combustion engine**

Schmitt, Paul S. Big Flats, NY, USA. Assigned to Corning

A method of manufacturing a catalytic converter having a non-round monolithic ceramic substrate comprising the steps of: wrapping a non-round monolithic ceramic substrate in a sufficient amount of the supporting mat material whereby the substrate peripheral surface is substantially covered; inserting the wrapped substrate into a metal shell which substantially surrounds the wrapped substrate; placing at least one force redistribution plug on the peripheral surface of the

metal shell and compressively closing the metal shell around the substrate; and securing the metal shell to provide a gas tight seal and to hold the compressive stress.

#### 5945080

##### **Catalyst and process for its production**

Hartweg, Martin; Heinau, Martina; Seibold, Andrea; Walz, Leonhard; Fetzer, Thomas; Morsbach, Bernd; Buechele, Wolfgang Erbach, Ulm, Blaustein-Arnegg, Neu-Ulm, Speyer, Ludwigshafen, Germany. Assigned to Daimler-Benz, BASF Aktiengesellschaft

A catalyst and a process for producing the catalyst are provided. For the catalytic reduction of  $\text{NO}_x$  and for the oxidation of hydrocarbons, the catalyst contains a spinel containing the metals copper, zinc and aluminum.

#### 05945369

##### **Catalyst for purifying exhaust gases and process for producing the same**

Kimura, Mareo; Matsuoka, Yoriko; Sobukawa, Hideo; Fukui, Masayuki; Suda, Akihiko; Kandori, Toshio; Ukyo, Yoshio Nagoya, Nisshin, Toyoake, Seto, Japan. Assigned to Kabushiki Kaisha Toyota Chuo Kenkyusho

A catalyst for purifying exhaust gases includes a porous support; a cerium oxide or a solid solution of a cerium oxide and a zirconium oxide in a state of mutual solid solution, loaded on the porous support; and a noble metal element loaded on the porous support. The cerium oxide or the solid solution has an average particle diameter of from 5 to 100 nm. The cerium oxide is present in the solid solution in an amount of from 0.2 to 4.0 by molar ratio with respect to the zirconium oxide therein. The catalyst can be prepared by: coating and calcinating on a support substrate a slurry of a cerium oxide sol, a cerium oxide sol and a zirconium oxide sol, on a solid solution powder of a cerium oxide and a zirconium oxide in a state of mutual solid solution; and loading a noble metal element thereon. The cerium oxide or its solid solution has a surface area large enough to effect an oxygen storage function, and has an average particle diameter large enough to prevent the same from entering deeply into fine pores of a porous support, thereby providing a catalyst fully exhibiting both of the oxygen storage capability and the catalytic activity.

#### 5955046

##### **Catalytic material for removing nitrogen oxides apparatus for treating nitrogen oxides using the material, and method of removing nitrogen oxides**

Okimura, Yasuyuki; Yokoi, Hitoshi; Ohbayashi, Kazushige; Hattori, Tadashi Inuyama, Aichi-ken, Nagoya, Japan. Assigned to NGK Spark Plug

A catalytic material for removing nitrogen oxides comprises a complex oxide as main phase. The complex oxide has a spinel structure and contains metallic elements of Al, Ga, and Zn. The mole fraction  $x$  (%) of Zn on oxide basis is greater than 0 and less than 50. Nitrogen oxides-containing gas and a reductant such as methane or propylene are brought into contact with the catalytic material so as to remove, through reduction, nitrogen oxides from the nitrogen oxides-containing gas. The catalytic material can be used to remove nitrogen oxides contained in exhaust gas from an automobile or the like. The catalytic material can remove nitrogen oxides even in exhaust gas of a high oxygen concentration and requires no toxic reductant such as ammonia.

#### **CATALYSIS FOR BULK AND FINE CHEMICALS**

#### 5936081

##### **Process for the hydrogenation of sugars using a shell catalyst**

Degelmann, Hanspeter; Kowalczyk, Jorg; Kunz, Markwart; Schuttenhelm, Matthias Worms, Bockenheim, Germany. Assigned to Sudzucker Aktiengesellschaft

The invention relates to a process for the hydrogenation of sugars and sugar mixtures to sugar alcohols or sugar alcohol mixtures wherein the sugars or sugar mixtures are hydrogenated with hydrogen in an aqueous solution at elevated temperature and elevated pressure by using a shell catalyst comprising a mixture of a pure Raney metal and a Raney metal alloy and wherein the shell catalyst has an essentially catalytically inactive core functioning as a carrier and a catalytically active shell.

#### 5939352

##### **Isobutanol synthesis catalyst — (LAW092)**

Vanderspurt, Thomas Henry; Greaney, Mark Alan; Leta, Daniel Paul; Koveal, Russell John; Disko, Mark Michael; Klaus, Angela V.; Behal, Sutinder K.; Harris,

Robert B. Delaware Township, Upper Black Eddy, Flemington, Baton Rouge, High Bridge, Highland Park, Somerville, Billings, MT, USA. Assigned to Exxon Research and Engineering

The invention relates to a catalyst for conversion of methanol, ethanol alone or in combination with *n*-propanol to isobutanol and the process for making and using the catalyst. The catalyst is a noble metal supported on at least a first phase of mixed oxide crystallites containing from about 60 to about 74 at.% (on a metals basis only) zirconium, from about 21 to about 31 at.% manganese and from about 5 to about 9 at.% zinc, and less than about 1 at.% alkali, a second phase of zirconium-doped hetaerolite particles containing from about 65 to about 69 at.% manganese, from about 31 to about 35 at.% zinc, from about 0.5 to about 5 at.% zirconium, and optionally a trace at.% of alkali, and a third phase containing from about 29 to about 55 at.% manganese, from about 13 to about 55 at.% zinc and from about 13 to about 35 at.% zirconium. The first phase mixed oxide crystallites have a zirconium oxide-like structure have a particle size of at least about 40 to about 100 Å, wherein the second phase particles have a particle size of about 200 Å to greater than about 2000 Å, and the third phase has a particle size of about 1000 Å to greater than 4000 Å.

#### 5939568

##### Accelerated catalysis of olefinic epoxidations

Sharpless, K. Barry; Rudolph, Joachim La Jolla, Krefeld, Germany. Assigned to The Scripps Research Institute

Rhenium-catalyzed epoxidation of olefinic substrates is accelerated by the use of accelerants having a nitrogenous aromatic heterocyclic structure. Use of the accelerants also enables the use of aqueous hydrogen peroxide as an oxidant. To achieve optimum acceleration, the accelerant should have a concentration within a range from 2.0 to 100 mol% of the accelerant with respect to 1 mol of the olefinic substrate. Use of the accelerant also results in an increased yield with respect to the conversion of the olefinic substrate to epoxide product.

#### 5942201

##### Process utilizing titanium dioxide as a catalyst for the hydrolysis of carbonyl sulfide

Hartmann, Achim Pulheim, Germany. Assigned to Kynos

The hydrolysis of carbonyl sulfide is substantially improved by utilizing titanium dioxide particles as a catalyst. It is especially favorable, if the titanium dioxide particle are sintered and treated with sodium hydroxide or sodium aluminate. Through such a treatment, the catalyst can be regenerated and reutilized.

#### 5942456

##### Multi-functional catalytic distillation structure

Crossland, Clifford S.; Adams, John R. Pasedena, TX, USA. Assigned to Catalytic Distillation Technologies

A catalytic distillation structure containing (1) a solid catalytic material comprising a catalyst component and (2) a structure. The total volume of open space for the catalytic distillation structure should be at least 10 vol.% and preferably at least 20 vol.% up to about 65 vol.%. The catalytic material may be a mixture of two or more catalysts or the individual catalyst may occupy separate and distinct areas of the structure without physical mixing of the catalysts. The structural element may contain substantially rigid elements and porous containers that contain the catalytic material. The structural element may be comprised of the porous containers. Other catalytic distillation structures may comprise the porous containers for the catalysts and a resilient material such as demister wire.

#### 5942460

##### Catalyst system

Garland, Carl Sherman; Giles, Martin Francis; Sunley, John Glenn Columbia, Ashford, North Humberside, Great Britain. Assigned to BP Chemicals

A process for the production of acetic acid by carbonylation of methanol or a reactive derivative thereof by contacting the methanol or derivative with carbon monoxide in a liquid reaction composition comprising (a) acetic acid, (b) an iridium catalyst, (c) methyl iodide, (d) at least a finite quantity of water and (e) methyl acetate is improved by the use as promoter of at least one of ruthenium and osmium.

#### 5942647

##### Process for the catalytic preparation of alkali metal alkoxides

Hamann, Carl Heinz; Schmittinger, Peter Ovelgoenne, Niederkassel, Germany. Assigned to Huels Aktiengesellschaft

Catalysts used for the catalytic preparation of alkali metal alkoxides from the alcohol and alkali metal amal-

gams are selected from the group consisting of carbides and nitrides of metals of Group VIa of the Periodic Table, and titanium carbide.

**5944905****Method and apparatus for performing a continuous reaction with at least one liquid phase and at least one solid catalyst in a pulsed column**

Faugeras, Pierre; Laporte, Françoise; Neau, Marie-Claude; Roux, Gabriel Pont Saint Esprit, Gardouch, Saint Laurent des Arbres, Meylan, France. Assigned to Agrichimie

A method and an apparatus for performing a continuous reaction with at least one liquid reaction phase incorporating at least one starting compound in the presence of at least one solid-phase catalyst, wherein the phases to be contacted are circulated through at least one pulsed reaction column. The liquid reaction phase is continuously fed into the middle or lower portion of the pulsed column, the liquid phase is circulated upwards through the pulsed column, and a counterflow made up of lumps of a solid selective extraction compound is continuously circulated. Furthermore, each solid catalyst is continuously circulated through the pulsed column in contact with the liquid phase.

**5945368****Molybdenum-modified vanadium-phosphorus oxide catalysts for the production of maleic anhydride**

Felthouse, Timothy R.; Keppel, Robert A.; Schaefer, Carl J. St. Louis, MT, USA. Assigned to Huntsman Petrochemical

An active catalyst having a crystal structure corresponding to that of a catalyst that has been prepared and activated by the following process. A substantially pentavalent vanadium-containing compound is reacted with a pentavalent phosphorus-containing compound in an alcohol medium capable of reducing the vanadium to an oxidation state of less than +5. Molybdenum is incorporated into the product of the reaction, thereby forming a solid molybdenum-modified precursor composition. The alcohol is removed to produce a dried solid molybdenum-modified precursor composition. Shaped bodies comprising said dried solid molybdenum-modified precursor composition are formed. The dried formed molybdenum-modified catalyst precursor composition is activated to transform it into the active catalyst.

**5945372****Catalyst for reacting organic compounds present in a gas mixture**

Landgraf, Norbert; Hums, Erich Ruckersdorf, Hessdorf, Germany. Assigned to Siemens Aktiengesellschaft

A particularly thermally stable and acid-resistant catalyst for reacting organic compounds present in a gas mixture, e.g., hydrocarbons, halogenated hydrocarbons, alcohols and solvents, includes titanium oxide, vanadium oxide and at least one further catalytically active component. The titanium oxide is predominantly present as titanium dioxide  $\text{TiO}_2$  of the rutile type having a BET surface area of greater than  $40 \text{ m}^2/\text{g}$ . The catalyst can be used for purifying combustion waste gases of all types and for purifying industrial waste air.

**5945551****Ethylene oxide catalyst**

Rizkalla, Nabil; Klein, Rita; Milne, Stephen Bruce Riverdale, Westwood, Wayne, NJ, USA. Assigned to Scientific Design

A silver catalyst for ethylene oxidation to ethylene oxide is provided containing a promoter combination consisting of an alkali metal component, a sulfur component, a germanium or tin component, and a fluorine component the catalyst being essentially free of rhenium and transition metal compounds.

**5945569****Catalyst and method for producing phenols**

Miki, Jun; Asanuma, Minoru; Konishi, Takeshi; Tachibana, Yakudo; Shikada, Tsutomu; Watanabe Aiko, Kawasaki-ku, Fujisawa, Japan. Assigned to NKK

A catalyst for producing phenols consists essentially of; an iron oxide; a nickel oxide; at least one first oxide selected from the group consisting of a vanadium oxide and a molybdenum oxide; and at least one second oxide selected from the group consisting of an alkali metal oxide and an alkaline earth metal oxide. The catalyst is used to produce phenols from benzoic acid or an alkyl benzoic acid.

**5945574****Olefin oligomerization process and catalysts therefor**

Chung, Tze-Chiang; Ding, Ruidong; Shubkin, Ronald L. State College, Baton Rouge, LO, USA. Assigned to BP Amoco

The use of novel heterogeneous catalyst complexes as catalysts for oligomerizing alpha-olefins is disclosed. The complexes are formed from (i) a solid olefin polymer having a linear backbone and a plurality of pendant omega-hydroxyalkyl groups, (ii) an organo-magnesium halide, and (iii) a boron trihalide, preferably  $\text{BF}_3$ . The complexes can be recovered and reused repeatedly in batch-type operations and can be used for long periods of time in continuous or semi-continuous operations without replenishment of their boron trifluoride content.

#### 5952258

##### **Process for the preparation of pyridine using zeolite catalysts**

Saitoh, Morihito; Tanaka, Yasutaka Hiroshima-ken, Japan. Assigned to Daicel Chemical Industries

Disclosed is a process for the preparation of pyridine bases by a reaction of an aliphatic aldehyde and/or ketone with ammonia under gaseous phase using a specified catalyst in which a specified metal or combined metals are carried in or onto specified zeolites, for example, such as zeolites having a specified specific density range.

#### 5955397

##### **Selective hydrogenation catalysts containing palladium, also tin and/or lead, and the preparation and use thereof**

Didillon, Blaise; Cameron, Charles; Gautreau, Christophe Rueil Malmaison, Paris, Rueil Malmaison, France. Assigned to Institut Francais du Petrole

A particulate selective hydrogenation catalyst for transforming unsaturated diolefinic hydrocarbons to alpha-olefinic hydrocarbons is described, for the hydrogenation of diolefinic compounds to alpha-olefinic compounds at rates which are at least 1.5 times higher than the rate of hydrogenation of alpha-olefinic hydrocarbons to saturated compounds. The catalyst contains palladium distributed at the periphery of particles (spherules or extrudates), and at least one element selected from tin and lead. Further, the tin and/or lead is advantageously distributed at the periphery of the spherules or extrudates. The catalyst preparation is also described, as well as a process for selective hydrogenation of diolefins to alpha-olefins using the catalyst.

## POLYMERIZATION CATALYSIS

#### 5936049

##### **Process for preparing solid titanium catalyst component, olefin polymerization catalyst and process for olefin polymerization**

Kojoh, Shinichi; Nakano, Masao Yamaguchi, Japan. Assigned to Mitsui Chemicals

Disclosed is a process for preparing a solid titanium catalyst component, comprising contacting (a) a liquid magnesium compound, (b) a liquid titanium compound, (c) an electron donor and (d) a solid divalent metallic halide. In this process, the solid divalent metallic halide is one having a crystalline structure of the cadmium chloride type. The contact of the component (a) with the component (b) is preferably carried out in the presence of the solid divalent metallic halide (d). According to this process, there can be obtained a solid titanium catalyst component capable of polymerizing olefins with an extremely high activity and capable of producing polyolefins of high stereoregularity when alpha-olefins of three or more carbon atoms are polymerized.

#### 5936051

##### **Substituted metallocene catalyst for the (co)polymerization of olefins**

Santi, Roberto; Borsotti, Giampiero; Querci, Cecilia; Gila, Liliana; Proto, Antonio Novara, Siena, Italy. Assigned to Enichem

Metallocene complexes of a metal M selected from titanium, zirconium and hafnium, comprising at least one anionic group A containing an  $\eta^5$ -cyclopentadienyl ring co-ordinated with the metal M, wherein the anionic group is substituted in at least one position of the cyclopentadienyl ring with a radical having the formula: wherein:  $\text{R}^6$  and  $\text{R}^7$  are independently hydrogen, halogen or a  $\text{C}_1$ - $\text{C}_4$  alkyl group, preferably hydrogen,  $n$  is 0 or 1, preferably 1,  $\text{Ph}^*$  is a  $\text{C}_6$ - $\text{C}_{14}$  group comprising an aromatic ring linked to  $-\text{CR}^6 \text{R}^7-$  or to A and substituted with at least one and up to a maximum of three electron-attractor groups, on the condition that, when A is an  $\eta^5$ -indenyl group and  $n$  is 0, at least one Ph group is linked to A in position 1 or 3 of indenyl. These complexes can be used in (co)polymerization processes of alpha-olefins, possibly in the presence of a suitable co-catalyst, for the production of polyolefins with a very high molecular weight.



**5939345****Prepolymerized solid catalyst, process for preparing the same, and process for heterogeneous polymerization of olefins**

Kobata, Atsuo; Matsumoto, Tetsuhiro Kuga-gun, Japan. Assigned to Mitsui Chemicals

A high-performance prepolymerized solid catalyst is prepared by polymerizing an olefin onto an olefin polymerization catalyst in a heterogeneous system under irradiation with an elastic wave, wherein the olefin is prepolymerized in an amount of not less than 0.1 g based on 1 mmol of a transition metal contained in the olefin polymerization catalyst. The elastic wave is preferably an ultrasonic wave.

**5939346****Catalyst system comprising an aryloxyaluminumoxane containing an electron withdrawing group**

Marks, Tobin J.; Yang, Xinmin; Mirviss, Stanley B. Evanston, Stamford, CT, USA. Assigned to Akzo Nobel, Northwestern University

Aryloxyaluminumoxanes containing the unit [Figure] where R is unsubstituted or substituted aryl, such as phenyl or naphthyl, are useful as cocatalysts in Ziegler–Natta and Kaminsky-type olefin polymerization catalysts. They can be formed by reaction of a source of water with an organoaluminum compound containing the desired aryloxy moiety or by reaction of preformed aluminumoxane with an organic compound, such as a phenol, containing such a moiety.

**5939347****Supported catalytic activator**

Ward, David George; Carnahan, Edmund Malott Laurel, Columbia, MD, USA. Assigned to W.R. Grace

A supported polyolefin catalyst activator, comprising a four coordinate anion having a direct chemical bond to a catalyst carrier, wherein said anion is comprised of a neutral, three coordinate compound,  $MR_3$ , and a carrier having oxygen containing functionalities, wherein M is selected from the group comprising boron, tellurium, aluminum, gallium, indium and mixtures thereof, and R's can be the same or different and are selected from the group comprising alkyls, alkoxy, alkenyls, halogen substituted alkyls, alkoxy, and alkenyls, aryls, aryl halides, halides and mixtures thereof; and a cation counter ion to said anion, wherein

said cation is a protonated base or a Lewis Acid capable of protonating or abstracting a moiety, such as an alkyl or aryl, from a transition metal containing catalyst precursor resulting in a cationic transition metal species.

**5939348****Catalyst for the manufacture of polyethylene with a narrow molecular weight distribution**

Mink, Robert I.; Nowlin, Thomas E. Warren, West Windsor Township, NJ, USA. Assigned to Mobil Oil

An ethylene–alpha-olefin copolymerization catalyst is prepared by impregnating a porous support, such as silica, with a contact mixture of an organomagnesium compound such as dialkyl magnesium and a silane compound which is free of hydroxyl groups, such as tetraethyl orthosilicate. A transition metal component such as titanium tetrachloride is then incorporated into the support in a specific ratio to the magnesium and silane components. Activation of this catalyst precursor with a trialkylaluminum compound results in a catalyst system which is effective for the production of ethylene copolymers.

**5939503****Group IV zwitterion ansa metallocene (ZAM) catalysts for alpha-olefin polymerization**

Goddard, III, William A.; Brandow, Christopher Pasadena, CA, USA. Assigned to California Institute of Technology

Single component metallocene catalysts for alpha-olefin polymerization are disclosed. Prior art cation metallocene catalysts have required a separate anion co-catalyst like methyl aluminumoxane (MAO). However, because the inventive zwitterion ansa metallocene (ZAM) catalysts have a “built-in” anion co-catalyst functionality, the need for a separate anion co-catalyst is eliminated.

**5942459****Catalysts for olefin polymerization and a process for preparing olefin polymers therewith**

Sugano, Toshihiko; Yamamoto, Kazuhiro Yokohama, Japan. Assigned to Mitsubishi Chemical

The object of the present invention is to provide a polyolefin having a good particle property in a high yield without use of an expensive alumoxane. The present invention comprises a catalyst for olefin poly-

merization comprising the following ingredients (A), (B) and (C), and a process for preparing an olefin polymer with use of the catalyst: Component (A): a transition metal compound having at least one conjugated five-membered ring ligand, the transition metal being in the Groups IV–VI of the Periodic Table, Component (B): an organoaluminum compound, and Component (C): a finely divided particle composition comprising 0.1–99.9% by weight of boric acid.

#### 5945366

##### **Solid catalyst component for polymerization of olefins and catalyst**

Kataoka, Takuo; Umebayashi, Hidetoshi; Goto, Kenji Kanagawa, Japan. Assigned to Toho Titanium

A solid catalyst component (A1) for polymerization of olefins prepared by contact with a solid component (d) obtained by allowing (1) a solid component (a) obtained by allowing (i) a dialkoxymagnesium or diaryloxymagnesium, (ii) a titanium compound and (iii) a diester of aromatic dicarboxylic acid to come in contact with one another and (2) a solid component (b) obtained by allowing (i) a dialkoxymagnesium or diaryloxymagnesium, (ii) a titanium compound, (iii) a diester of aromatic dicarboxylic acid and (iv) a polysiloxane to come in contact with one another, to come in contact with each other, or a solid catalyst component (A2) for polymerization of olefins prepared by allowing said solid component (a) and (3) a solid component (d) obtained by allowing (i) a dialkoxymagnesium or diaryloxymagnesium, (ii) a titanium compound, (iii) a diester of aromatic dicarboxylic acid, (iv) a polysiloxane and (v) an aluminum compound to come in contact with one another, to come in contact with each other. Optionally, an organic aluminum compound (B) and organic silicon compound (C) can also be co-reacted to form the catalyst.

#### 5948872

##### **Solid titanium catalyst component for olefin polymerization olefin polymerization catalyst prepolymerized polyolefin-containing catalyst and method of olefin polymerization**

Kioka, Mamoru; Shinozaki, Tetsunori Kuga-gun, Japan. Assigned to Mitsui Chemicals

A solid titanium catalyst component Ia containing magnesium, halogen, titanium and a compound having at least two ether linkages with a plurality of intermedi-

ately existing bonding atoms; a catalyst and a prepolymerized olefin-containing catalyst prepared by using the solid titanium catalyst component Ia, a method for preparing a polyolefin wherein said catalyst or prepolymerized olefin containing catalyst is used. A catalyst and a prepolymerized olefin containing catalyst prepared by using a solid titanium catalyst component Ib, containing magnesium, halogen, titanium and a specific electron donor (al), and a compound having at least two ether linkages with a plurality of intermediately existing bonding atoms; a method for preparing a polyolefin wherein said catalyst or prepolymerized olefin containing catalyst is used. By virtue of the use of the catalysts or the prepolymerized olefin-containing catalysts, the polymerization reaction efficiently proceeds with high catalytic activity, giving polymers high in stereospecificity.

#### 5948874

##### **Acid catalyzed polymerization**

Pike, William C.; Priddy, Duane B. Midland, Midland, MI, USA. Assigned to The Dow Chemical

The present invention is an improvement in a free radical bulk polymerization process for preparing a high molecular weight polymer from a vinyl aromatic monomer characterized in that the polymerization is conducted in the presence of an acid catalyst having a  $pK_a$  at 25°C of less than 2, or salt thereof, wherein the improvement comprises dispersing the acid catalyst, or salt thereof, in a (meth)acrylic acid or ester thereof, prior to contact with the vinyl aromatic monomer. The (meth)acrylic acid or ester allows the acid catalyst to be dispersed within the vinyl aromatic monomer without causing cationic polymerization. The acid catalyst, or salt thereof, catalyzes the free radical polymerization reaction such that high molecular weight polymers are produced in reasonable reaction times.

#### 5955625

##### **Monocyclopentadienyl metal compounds for ethylene- $\alpha$ -olefin-copolymer production catalysts**

Canich, Jo Ann Marie Webster, TX, USA. Assigned to Exxon Chemical Patents

Described are certain monocyclopentadienyl Group IV B metal compounds, catalyst systems comprising such monocyclopentadienyl metal compounds and an activator, and a process using such catalyst systems for the production of polyolefins, particularly high molecu-

lar weight ethylene- $\alpha$ -olefin copolymers having a high level of  $\alpha$ -olefin incorporation.

## REFINERY CATALYSIS AND PROCESSES

### 5935415

#### Continuous catalytic reforming process with dual zones

Haizmann, Robert S.; Park, John Y.G.; Russ, Michael B. Rolling Meadows, Naperville, Villa Park, IL, USA. Assigned to UOP LLC

A hydrocarbon feedstock is catalytically reformed in a sequence comprising a continuous-reforming zone, consisting essentially of a moving-bed catalytic reforming zone and continuous regeneration of catalyst particles, and a zeolitic-reforming zone containing a catalyst comprising a platinum group metal and a non-acidic zeolite. The process combination permits higher severity, higher aromatics yields and/or increased throughput in the continuous-reforming zone, thus showing surprising benefits over prior-art processes, and is particularly useful in upgrading existing moving-bed reforming facilities with continuous catalyst regeneration.

### 5935419

#### Methods for adding value to heavy oil utilizing a soluble metal catalyst

Khan, Motasimur Rashid; DeCanio, Steven Jude Wappingers Falls, Montgomery, NY, USA. Assigned to Texaco

A process for the upgrading a heavy oil to a lighter oil having a higher API gravity than the heavy oil is disclosed. The process includes reacting an emulsion of the heavy oil with water in the presence of a catalyst and a hydrogen containing gas to give a reaction product from which the light oil is recovered. The process may also include the gasification of the heavy oil residue and the hydrocarbon containing water portions of the above reaction product for use in the upgrading process. The catalyst is preferably soluble in either oil or water portion of the emulsion and includes a transition metal containing compound, the metal being selected from Groups V, VI, and VIII of the Periodic Table or mixtures of these metals.

### 5936126

#### Process for reacting an organic compound in the presence of a supported ruthenium catalyst

Ruhl, Thomas; Breitscheidel, Boris; Henkelmann, Jochem; Reif, Wolfgang; Menig, Helmuth; Weiguny,

Sabine Frankenthal, Limburgerhof, Mannheim, Friedelsheim, Freinsheim, Germany. Assigned to BASF Aktiengesellschaft

A process for the hydrogenation of an aromatic compound, in which at least one hydroxyl group is attached to an aromatic core, or an aromatic compound, in which at least one amino group is attached to an aromatic core, in the presence of a catalyst containing, as active metal, ruthenium and optionally one or more other Group IB, VIIB, or VIIB metals, applied to a macroporous support.

### 5942651

#### Process for converting $C_{9+}$ aromatic hydrocarbons to lighter aromatic products by transalkylation in the presence of two zeolite-containing catalysts

Beech, Jr., James H.; Hellring, Stuart Damon; Helton, Terry Eugene; Kinn, Timothy Frederick; Mizrahi, Sadi; Rouleau, Norman J. Wilmington, Yardley, Glen Mills, Humble, Cherry Hill, Yardley, PA, USA. Assigned to Mobile Oil

A process for converting a heavy aromatics feed to lighter aromatic products, such as benzene and xylene, by reacting  $C_{9+}$  aromatic hydrocarbons and toluene or benzene under transalkylation reaction conditions, over a first catalyst composition including a zeolite having a constraint index ranging from 0.5 to 3 and a hydrogenation component and a second catalyst composition including an intermediate pore size zeolite having a constraint index ranging from 3 to 12 and a silica to alumina ratio of at least about 5, to produce a transalkylation reaction product containing benzene or toluene and xylene. The benzene or toluene from the reaction product can then be distilled to obtain a benzene or toluene product.

### 5944983

#### Hydrotreating catalyst and hydrotreating process of hydrocarbon oil by using the same

Hayashi, Fumitaka; Kamo, Akira; Toshima, Hiroshi; Saiai, Akira Tokyo, Saitama, Japan. Assigned to Tonen

This invention relates to a hydrotreating catalyst for a hydrocarbon oil and also to a process for hydrotreating the hydrocarbon oil by using the catalyst. More specifically, the present invention is concerned with a hydrotreating catalyst formed by having a hydrogenation

tion-active component supported on a silica–alumina carrier and having a specific pore distribution and also with a hydrotreating process making use of the catalyst for the removal of sulfur compounds and nitrogen compounds from a hydrocarbon oil.

#### 5945364

##### **Catalyst composition comprising acid–base leached zeolites**

Wu, An-hsiang; Drake, Charles A. Bartlesville, Nowata, OK, USA. Assigned to Phillips Petroleum

A catalyst composition and a process for hydrodealkylating  $C_{9+}$  aromatic compounds such as, for example, trimethylbenzenes, to  $C_6$  to  $C_8$  aromatic hydrocarbons such as toluene and xylenes are disclosed. The composition comprises an alumina and a silica wherein the weight ratio of aluminum to silicon is in the range from about 0.005:1 to about 0.25:1. The process comprises contacting, in the presence of the catalyst composition, a fluid which comprises a  $C_{9+}$  aromatic compound with a hydrogen-containing fluid under a condition sufficient to effect the conversion of a  $C_{9+}$  aromatic compound to a  $C_6$  to  $C_8$  aromatic hydrocarbon; and the  $C_{9+}$  aromatic compound contains at least 9 carbon atoms. Also disclosed is a process for producing the catalyst composition which comprises: (1) contacting a zeolite with an effective amount of a base under a condition sufficient to effect a reduction in silicon content of said zeolite to produce a base-leached zeolite; and (2) contacting said base-leached zeolite with an effective amount of an acid under a condition sufficient to effect a reduction in aluminum content of said base-leached zeolite.

#### 5945371

##### **Catalyst composition and processes therefor and therewith**

Wu, An-hsiang; Drake, Charles A. Bartlesville, Nowata, OK, USA. Assigned to Phillips Petroleum

A catalyst composition and a process for hydrodealkylating a  $C_{9+}$  aromatic compound to a  $C_6$  to  $C_8$  aromatic hydrocarbon are disclosed. The composition comprises an alumina, molybdenum oxide, and zinc oxide. The process comprises contacting a fluid which comprises a  $C_{9+}$  aromatic compound with the catalyst composition under a condition sufficient to effect the conversion of a  $C_{9+}$  aromatic compound to a  $C_6$  to  $C_8$  aromatic hydrocarbon. Also disclosed is a process for

producing the composition which comprises: (1) contacting an alumina, which can be optionally calcined before being contacted, with a molybdenum compound and zinc compound in a liquid medium under a condition sufficient to incorporate the molybdenum compound and zinc compound into the alumina to form a modified alumina wherein the volume of the liquid medium is larger than the bulk volume of alumina; (2) removing the excess liquid medium; (3) drying the modified alumina; and (4) calcining the modified alumina to a Mo/Zn-promoted alumina under a condition sufficient to effect the conversion of the molybdenum compound and zinc compound to corresponding oxides.

#### 5948239

##### **Process for obtaining distillate fuel products using a multi-bed catalytic reactor**

Viridi, Harjeet S.; Klein, Benjamin; McNab, R. John SugarLand, Houston, Randolph, TX, USA. Assigned to ABB Lummus Global

Disclosed herein is a highly efficient process for producing distillate fuels using a multi-bed hydrogenation reactor. The temperature of the feed to the second and subsequent reactor beds is controlled by removing effluent from the prior bed, cooling the effluent in an external heat exchanger, injecting hydrogen gas into the effluent mixture, and inserting the cooled mixture containing hydrogen gas into the inlet of the next reaction zone.

#### 5951847

##### **Catalytic dehazing of lubricating base oils**

Grandvallet, Pierre; Huve, Laurent Georges Grand Couronne, France. Assigned to Shell Oil

A process for catalytically dehazing lubricating base oils is disclosed, which comprises contacting the lubricating base oil in the presence of hydrogen with a catalyst comprising naturally occurring and/or synthetic ferrierite which ferrierite has been modified to reduce the mole percentage of alumina and a low acidity refractory oxide binder material which is essentially free of alumina.

#### 5951850

##### **Process for fluid catalytic cracking of heavy fraction oil**

Ino, Takashi; Ikeda, Satoru Yokohama, Yokohama, Japan. Assigned to Nippon Oil, Petroleum Energy Center

A heavy fraction oil is catalytically cracked by contacting the oil with a catalyst containing an ultra-stable Y-type zeolite, in a fluid catalytic cracking apparatus having a regenerating zone, a reaction zone, a separation zone and a stripping zone and under conditions that a reaction zone outlet temperature is in a range of 550–700°C, a catalyst/oil ratio is in a range of 15–100 wt./wt., and a difference between a regenerating zone catalyst concentration phase temperature (1) and the reaction zone outlet temperature (2) is in a range of 5–150°C. According to the fluid catalytic cracking process, an amount of dry gases generated by the thermal cracking of the heavy fraction oil can be lessened while a yield of light fraction olefins can be enhanced.

#### 5952535

##### **Selective catalytic conversion of a C<sub>9</sub> aromatic feedstock containing substantial amounts of ethyl substituted aromatic components to a product rich in toluene and/or xylenes**

King, David L.; Derouane, Eric G.; DeDeken, Jacques C.; Masuda, Toshihiko; Nishikawa, Shinji; Fujii, Hiroshi; Adachi, Masaaki Mountain View, Liverpool, Palo Alto, Sagamihara, Kawasaki, Sunnyvale, Japan. Assigned to Catalytica

This invention is an improved process for the conversion of a C<sub>9</sub> mixed alkyl aromatic feedstream containing ethyl substituted aromatics to a product rich in toluenes and/or xylenes via catalytic transalkylation/disproportionation using a palladium loaded moderately, dealuminated mordenite catalyst in the presence of added hydrogen and benzene.

#### 5954942

##### **Catalytic cracking with delayed quench**

Adornato, Peter M.; Avidan, Amos A.; Johnson, David L. Cherry Hill, Yardley, Glen Mills, PA, USA. Assigned to Mobil Oil

A process for thermally and catalytically upgrading a heavy feed in a single riser reactor FCC unit is disclosed. A heavy feed is cracked in the base of the riser at higher than normal cracking temperatures for at least 1.0 s of vapor residence time, then quenched. Quenching with large amounts of quench, preferably downstream of the mid point of the riser, increases conversion as compared to use of the same amount of quench within one second. Small amounts of quench,

near the riser outlet, crack heavy feed roughly as well as large amounts of quench, near the base of the riser. High velocity, atomizing quench nozzles reduce riser pressure and/or catalyst slip in downstream portions of the riser, further increasing gasoline selectivity and reducing coke yields.

#### 5954946

##### **Hydrocarbon conversion catalysts**

Klazinga, Aan Hendrik; Maesen, Theodorus Ludovicus Michael; Van Veen, Johannes Anthonius Robert; Van Vegchel, Ingrid Maria Amsterdam, Netherlands. Assigned to Shell Oil

The present invention provides a catalyst comprising a very ultrastable zeolite Y (VUSY) in which less than 15% of the total amount of aluminum (Al) present is octahedrally coordinated; a process for preparing the zeolite; and a hydrocarbon conversion process using the catalyst.

#### ORGANOMETALLIC CATALYSIS

#### 5936109

##### **Ligands for asymmetric catalysis**

Berens, Ulrich Cambridge, Great Britain. Assigned to Chirotech Technology

The subject invention relates to phosphine ligands that are useful for asymmetric reactions, especially as chiral ligands for catalytic asymmetric hydrogenation.

#### 5936127

##### **Asymmetric synthesis and catalysis with chiral heterocyclic compounds**

Zhang, Xumu State College, PA, USA. Assigned to The Penn State Research Foundation

This invention relates to chiral heterocyclic compounds useful for asymmetric synthesis and catalysis. More particularly, the invention relates to chiral heterocyclic phosphine, sulfur, and nitrogen compounds for asymmetric synthesis and catalysis in the production of enantiomerically pure products.

#### SYNGAS CONVERSION

#### 5939350

##### **Processes and catalysts for conducting Fischer–Tropsch synthesis in a slurry bubble column reactor**

Singleton, Alan H.; Oukaci, Rachid; Goodwin, James G. Marshall Township, Allegheny County, Allison Park,

Cranberry Township, PA, USA. Assigned to Energy International

Processes and catalysts for conducting Fischer–Tropsch synthesis in a slurry bubble column reactor (SBCR). One aspect of the invention involves the use of cobalt catalysts without noble metal promotion in an SBCR. Another aspect involves using palladium promoted cobalt catalysts in an SBCR. Methods for preparing noble metal promoted catalysts via totally aqueous impregnation and procedures for producing attrition-resistant catalysts are also provided.

#### **5972175**

##### **Catalytic microwave conversion of gaseous hydrocarbons**

Tanner, Dennis D.; Ding, Qizhu Edmonton, Canada. Assigned to Governors of the University of Alberta

The method of the present invention is for producing at least hydrogen from a gaseous hydrocarbon. The gaseous hydrocarbon is selected from the group consisting of methane, ethane, butane, propane and combinations thereof. The method proceeds by exposing the gaseous hydrocarbon with the supported catalyst to microwave radiation. The supported catalyst has a support of a lattice of a non-metallic amorphous solid and at least one catalytic metal having atoms interspersed throughout the lattice of the support. A preferred embodiment is a lattice of carbon with at least one catalytic metal interspersed throughout the lattice. Examples include char.

#### **5981608**

##### **Catalyst and process for the preparation of hydrocarbons**

Geerlings, Jacobus Johannes Cornelis; Goes, Marinus Franciscus; Huisman, Hans Michiel; Lange, Jean-Paul; Oosterbeek, Heiko; Rek, Paulus Johannes Maria;

Schaddenhorst, David Amsterdam, Netherlands. Assigned to Shell Oil

The present invention relates to a catalyst for use in a process for the preparation of hydrocarbons comprising cobalt and manganese and/or vanadium, supported on a carrier, wherein the cobalt:(manganese + vanadium) atomic ratio is at least 12:1. Preferably, the cobalt:(manganese + vanadium) atomic ratio is at most 1500:1. The invention further relates to a process for the preparation of hydrocarbons which comprises contacting a mixture of hydrogen and carbon monoxide at elevated temperature and pressure with a catalyst as described hereinbefore. Typically, at least part of the cobalt is present in the metallic state.

#### **5985178**

##### **Low hydrogen syngas using CO<sub>2</sub> and a nickel catalyst**

Long, David C.; Fiato, Rocco A. Baton Rouge, Basking Ridge, NJ, USA. Assigned to Exxon Research and Engineering

A process for making a synthesis gas comprising H<sub>2</sub> and CO in the presence of a reforming catalyst comprising a supported non-noble Group VIII metal catalytic component from a feed including a low molecular weight alkane, and preferably methane as in natural gas, O<sub>2</sub>, H<sub>2</sub>O and CO<sub>2</sub> without catalyst deactivation is achieved by partially oxidizing and steam reforming the feed in the presence of the catalyst. The feed H<sub>2</sub> O to hydrocarbon carbon mole ratio is less than 2. The mole ratio of the combined feed CO<sub>2</sub> and H<sub>2</sub> O to hydrocarbon carbon ranges from 0.5 to 2.5 and that of the feed H<sub>2</sub>O to CO<sub>2</sub> ranges from 0.35 to 6. Synthesis gas having H<sub>2</sub> to CO mole ratios less than 2:1 and even less than 1.5:1 are easily achieved with net CO<sub>2</sub> consumption, which also makes the process environmentally beneficial.